Small-scale Forestry (2014) 13:445–460
DOI 10.1007/s11842-014-9264-8

RESEARCH PAPER

Climate Change Effects on Community Forests: Finding Through User's Lens and Local Knowledge

Mohammed Alamgir · Jürgen Pretzsch · Stephen M. Turton

Accepted: 23 February 2014 / Published online: 15 March 2014

Abstract About 35 % of the population of Nepal (1.45 M households) has been engaged in community forestry, depending on the activity for their livelihoods and community development. Climate change is threatening community forestry, for which impacts are likely to be greater than many other sectors, but little scientific information is available. Hence, local knowledge—as drawn on in this paper—is expected to beneficial for conservation planning and climate change adaptation strategies. The analysis is based on a focus group discussion and a survey of 31 members of Thotne Khola Community Forest User Group in Kaski, Nepal. Locally identified climate change effects on community forests and related causes include: coppiced *Schima wallichii* and *Castanopsis indica* is dying due to higher summer temperatures, increased pest infestations due to higher summer temperatures and delayed rainfall; more wilted trees due to higher summer temperatures; and more droughts and extended summers. A highly effected tree is *Myrica esculenta*, the fruit of which are ripening 10–15 days earlier due to higher temperatures in early winter, and have become less palatable and have accumulated more water due to more rainfall in early Chaitra (mid-March to mid-April). Climate change effects identified using local knowledge are aligned with related scientific observations available in published literature. It is concluded that drawing on local knowledge should be accepted as a legitimate approach for climate change adaptation strategies and forestry-related policy in the developing world, where science-based information availability is often lacking.

M. Alamgir (✉) · S. M. Turton
Centre for Tropical Environmental and Sustainability Sciences, School of Earth and Environmental Sciences, James Cook University, Cairns, QLD 4870, Australia
e-mail: alamgirmds@gmail.com; mohammed.alamgir@my.jcu.edu.au

M. Alamgir · J. Pretzsch
Institute of International Forestry and Forest Products, Technical University of Dresden, 01737 Tharandt, Dresden, Germany

Keywords Phenology · *Myrica esculenta* · Pest infestation · Invasive plants · Conservation planning · Adaptation · Middle hills

Introduction

Climate change and its effects on various sectors of the economy, including forestry, is one of the most important global concerns as researchers have revealed adverse effects of climate change on forests, ecosystems, agriculture, livelihoods and many other resources across the world. Munang et al. (2013) argued that climate change is affecting millions of people and their efforts to reduce poverty. Chaudhary and Bawa (2011) argued that consequences of climate change for biodiversity, ecosystem services and human wellbeing in the Himalayas will be more severe than in many other parts of the world. The Himalayas is one of 34 identified global hotspots for biodiversity (Myers et al. 2000). More than 750 million people live in the Himalayan region (Chaudhary and Bawa 2011). Apart from huge environmental services, forests in this region are vital resources for livelihood activities, particularly for poor local people. In Nepal, community people manage community forests for their livelihoods and community development utilizes forest resources, ensuring sustainable forests management (Department of Forests, Nepal 2012). Hence, any effects of climate change on community forests will not only disrupt ecosystem functioning and biodiversity but also the livelihoods of community people and sustainable community development. Most of the forest-dependent people in Nepal have few alternative livelihood options, coupled with low adaptive capacity due to limited information and poor access to services and lack of social welfare (Gentle and Maraseni 2012). Sharma (2011) argued that Nepal is more vulnerable than many other countries to the adverse impacts of climate change due to its mountain geography. Gentle and Maraseni (2012) argued that the negative impacts of climate change on Nepal are significant due to its fragile economic and environmental base.

Aligning with the global climate change trends, the climate in Nepal is also changing. In Nepal, from 1977 to 1994 the mean annual temperature increased by 0.06 °C per year (Shrestha et al. 1999; Ebi et al. 2007). It is reported that annual temperatures in Nepal are rising 0.41 °C per decade (Shrestha et al. 2000; Kansakar et al. 2004; Dahal 2005). In fact, the warming rate is even higher than the global average (Du et al. 2004; Baidya et al. 2008) and the warming rate is higher in the Mountain and the Middle hill zone than the Terai (lowland) (Shrestha et al. 1999, 2000). Furthermore, an increasing trend rate of rising temperatures has been projected for this century (IPCC 2007). Apart from temperature rise, observed climate change phenomenon in Nepal include: changing precipitation patterns; glacier recession; less predictable timing of onset of monsoon seasons; and increasing incidence of severe storms, landslides and droughts (Sharma 2011; Gentle and Maraseni 2012). The adverse impacts of climate change on agriculture, forests, water bodies and human health in Nepal have been reported by several researchers e.g. Malla (2008), Regmi et al. (2008), Manandhar et al. (2011). It is also reported that climate change impacts, such as unpredictable rainfall, longer

droughts, floods, water scarcity, landslides and decreased food productivity are increasing both in magnitude and frequency in Nepal (Anonymous 2009).

Community Forestry (CF) in Nepal has made enormous contributions to biodiversity conservation, improving forest conditions, empowerment of women, community development and improved livelihoods (Department of Forests, Nepal 2012; Gurung et al. 2013). CF is also playing a vital role in total carbon sequestration in Nepal (Shrestha et al. 2013). Moreover, the Nepal CF experience has increasingly gained worldwide recognition as a highly successful program (Gautam et al. 2004). In Nepal, CF has been practiced since 1978 although the current concept of Community Forest User Groups (CFUGs) was introduced in 1993. Community forests are managed by CFUGs as legitimized autonomous bodies under the *Forest Act 1993* and Regulation 1995 (Bhattacharya and Basnyat 2003). The policy of the government is to hand over the accessible forests as community forests to the CFUGs for management and utilization of forest resources (Department of Forests, Nepal 2012). Up to 2012, about 35 % of the population of Nepal (1.45 M households) had been involved in CF (Department of Forests, Nepal 2012). These local people depend heavily on community forests for their livelihood activities as well as community development activities including building schools, road construction and constructing potable water facilities. Climate change threatens their livelihoods and community development.

Local knowledge is importantly recognized in the latest climate change policy arenas (such as REDD+) for facilitating sustainable forest management. Scientists also believe that local communities' indigenous knowledge is beneficial for climate science and policy (Cruikshank 1981; Reidlinger and Berkes 2001; Moller et al. 2004; Akhter et al. 2013). Globally, several studies on indigenous knowledge have been conducted on the topics of perceptions about climate change (Vedwan and Rhoades 2001; Duerden 2004; King et al. 2008; Martello 2008; Byg and Salick 2009; Salick and Ross 2009; Sharma et al. 2009), and consequences of climate change for biodiversity and agriculture (Chaudhary and Bawa 2011). Climate change effects in Nepal has been studied in few research projects (Gautam et al. 2010), and most of this research have been undertaken on climate change and its effect on community forests with respect to both biophysical and social dimensions (Jianchu et al. 2007). Therefore, this study investigates climate change effects on community forests using local knowledge and addresses the following three questions: (1) how do local users identify climate change effects on community forests? (2) what causes do local users perceive for each effect on community forests? and (3) how do local users identify effects and related causes consistent with available scientific observations?

The Study Site

The study has been conducted in Thotne Khola Community Forest User Group, which has managed Thotne Khola Community Forest since May 1998. The group consists of 148 members. Thotne Khola Community Forest is located at Sarangkot VDC (Village Development Committee), Kaski District, Nepal (Fig. 1), with a total

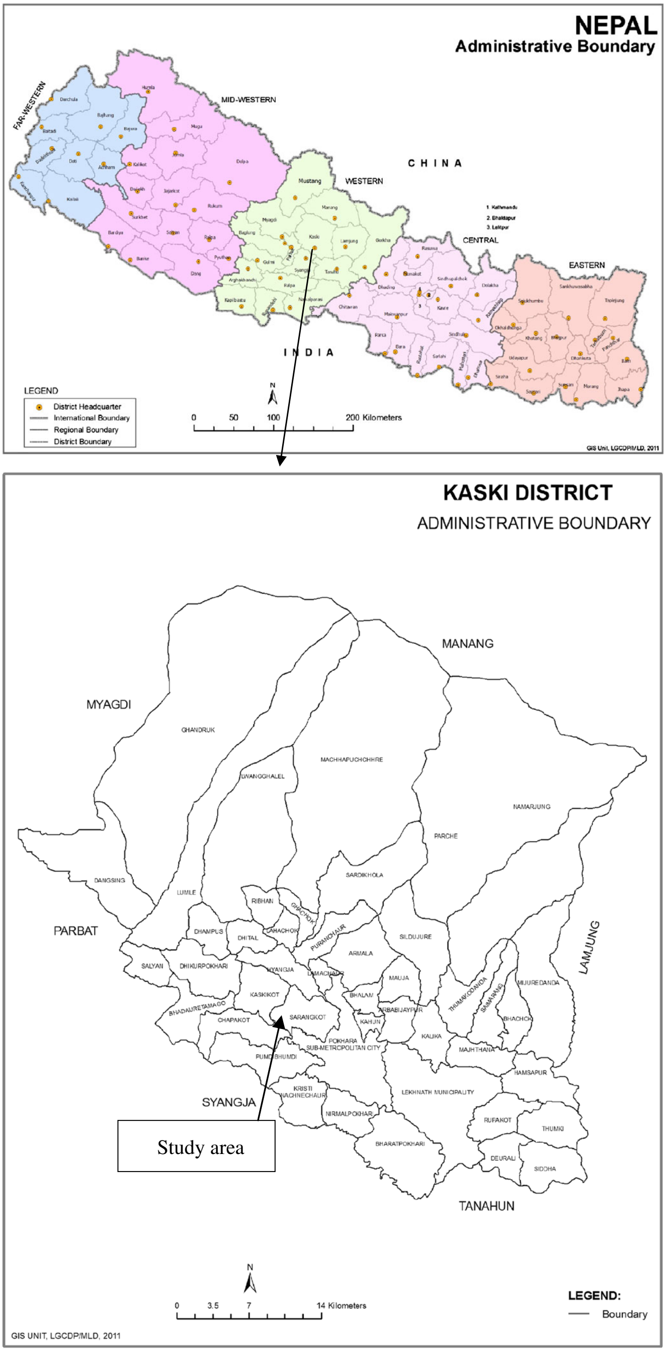

Fig. 1 *Top panel* District map of Nepal showing the study District (Kaski), *bottom panel* map of Village Development Committee (VDC) of Kaski district, Nepal showing the study area (Sarangkot VDC). *Source*: Government of Nepal (2013)

area of 81.5 ha. An 11 member non-political executive committee is elected out of 148 members for each operational plan period (5 years). Of the 11 members, three are female and eight male, one member is from a lower caste and three are from indigenous groups. The executive committee is responsible for forest conservation and rational use of forest resources for social and economic development of the community following the respective community forests constitution and operational plan. Out of six units, VDCs are the fourth level units in the administrative hierarchy in Nepal (Manandhar et al. 2011).

Thotne Khola Community Forest is a *Schima wallichii* (Chelauni) and *Castanopsis indica* (Katus) dominated mixed deciduous forest where *Alnus nepalensis* (Utish), *Myrica esculenta* (Kafa) and *Madhuca latifolia* are associated trees. Among three land categories in Nepal (terrai, middle hills and mountains), Thotne Khola Community Forest is located in the middle hill zone at about 1,600 m altitude. The forest was previously degraded by grazing, forest fires and illegal cutting. To facilitate recovery, the government handed over the forest for community management. Prohibited activities include: purchasing, selling and transferring ownership of forest land; forest destruction and deforestation; shifting cultivation; any construction work; activities that promote landslides and soil erosion; and hunting and capturing wild animals and removal of soil, sand, rock, and pebbles. Permitted activities include: sale of up to a prescribed amount of timber; forest-based small-scale enterprises; growing seedlings in nurseries as per community need; planting non-timber forest products (NTFPs) under trees and in the natural open space of forests; collection and distribution within the community of timber and fuelwood after silvicultural operations; and collection of grasses, litter from forest floor, wood for agricultural tools, naturally fallen firewood, fruits of chestnuts and any other NTFPs. Furthermore, at least 25 % of income from community forest will have to be invested in community forest development and the remainder in community development. Prescribed silvicultural activities in the operational plan include:

- Retaining the best coppice from many sprouts of each stump of *S. wallichii* and *C. indica*. During the first operation CFUG cut all sprouts except the best three (healthy and straight); in second operation (after 6 years of first operation), CFUG cut all remaining sprouts except the best one from each stump, a procedure known as *singleing*.
- Thinning, pruning and cleaning to make stands productive in a specific plan period.
- Removal of diseased, dead, dying and deformed (4D) trees.

It is assumed that extensive work experience in community forests management is necessary for identifying climate change effects. Hence, older CFUGs should have the greatest understandings of climate change effects on community forests. Therefore, the following criteria were used for selection of the CFUG: (1) age of CFUG, i.e. officially handed over the forest at least 10 years before the present study; (2) at the stage of substantial harvesting and benefit sharing; and (3) presence of some intervention in forest management. These attributes of the selected CFUG were as follows: the age of Thotne Khola Community Forest User Group was 13 years; the operational plan of Thotne Khola Community Forest was revised in

2004; and the CFUG planted medicinal plants in Thotne Khola Community Forest. Furthermore, accessibility to the researcher was also considered in selecting the CFUG.

Research Method

A survey of 31 members of Thotne Khola Community Forest User Group in Kaski, Nepal was conducted using a semi-structured questionnaire. The 31 respondents out of 148 members were selected randomly. Initially, five members (one school teacher, two members of executive committee, one elderly woman and one elderly man who regularly visited the forest) were surveyed to test the questionnaire. The final questionnaire included questions about demography and involvement of respondents with CF, understanding about climate change, knowledge about observed changes in structure and composition of community forests and reasons for identified changes. During analysis of the results of the household survey, a list of identified observed changes in community forests with respective identified climatic causes was prepared. A focus group discussion was arranged confirming the list after minor corrections. Twenty members of Thotne Khola Community Forest User Group (male, female, young, old, member of executive committee) were present for the focus group discussion for an hour. Finally, Thotne Khola Community Forest was visited to triangulate the provided information with on-ground effects.

Study Findings

Demography of the Respondents

Of the 31 respondents, 68 % were female, 58 % were more than 50 years old and 94 % have engaged with Thotne Khola Community Forest management for more than a decade (Tables 1 and 2). Just under half (48 %) of respondents had completed at least primary schooling (Table 2). Most of the respondents (61 %) practiced farming as their primary occupation, whereas 32 % collected forest products as their secondary occupation (Table 3). Regardless of occupation, all respondents have entered into the forest to collect forest products either for their household use or to sell into the market for additional income, although they engaged in some other secondary occupation (usually agriculture, services and small business).

Understanding of the Respondents About Climate Change

Of the 31 respondents, 45 % mentioned that they know about climate change. The studied community forest is in the remote area where about half of the respondents are illiterate and there is no electricity connection in some houses. They build their houses within the forest area, collect forest products and practice farming either on their own land or land owned by others for their day-to-day life, rarely being interested in other issues including climate change (users' opinion). So they

Table 1 Sex and age classes of the respondents

Respondent frequency	Sex			Age			
	Male	Female	Total	<30 years	30–50 years	>50 years	Total
Number	10	21	31	4	9	18	31
Relative frequency (%)	32.3	67.7	100	12.9	29	58.1	100

Table 2 Educational status of respondents and the time period respondents have engaged in community forest management

Educational status	Frequency[a]	Time period engaged in community forest management	
		Time period	Frequency
Illiterate	16 (51.6)		
Primary (up to class 5)	3 (9.7)	<5 years	1 (3.2)
Lower secondary (up to class 8)	3 (9.7)	5–10 years	1 (3.2)
Higher secondary (up to class 12)	9 (29.0)	>10 years	29 (93.6)
Total	31 (100)	Total	31 (100)

[a] The figures in parenthesis are percentages

Table 3 Primary and secondary occupation of the respondents

Occupation	Primary	Secondary
	Frequency[a]	Frequency
Forest product collection and sale	0 (0.0)	10 (32.3)
Farming (work in their own land)	15 (48.4)	6 (19.3)
Farming (work in others' land)	4 (12.9)	0 (0.0)
Services	6 (19.4)	2 (6.5)
Small business	5 (16.1)	6 (19.3)
Others	1 (3.2)	7 (22.6)
Total	31 (100)	31 (100)

[a] The figures in parenthesis are percentages

generally do not know about climate change. Among the 45 % of the respondents who knew about climate change, most (29 %) heard about climate change jointly from friends, family and the media (Table 4). The media was a common source for the users knowing about climate change. Importantly, 7 % of users are aware of climate change because they recognize changes in climatic elements including temperature and rainfall. An additional 7 % of users understand climate change from their practical experiences. As they work in the fields they can explain the changes in climatic components. One user's statement about climate change was that "in winter previously we used to wear light clothes and no sandals but now we have to wear more clothes and sandals and also found cracks in the skin on our

Table 4 Sources of understanding of Community Forest User Group about climate change

Source of knowledge	Frequency (%)
Friends and family	7.1
Media	14.3
Observation	7.1
Practical experiences	7.1
Friends, family, media and observation	21.4
Friends, family and media	28.6
Observation and practical experiences	14.3
Total	45.2

legs". Therefore, it is evident that users are able to understand climate change from their practical experiences.

Climate Change Effects on Community Forests

Members of Thotne Khola Community Forest User Group (users) explained their local knowledge of the observed variation in forest structure and composition on Thotne Khola Community Forest, climate-related causes of variation if any and experiences of observations of variations of climatic components and related effects. The identified climate change components reported to be affecting community forests are higher annual temperatures, higher summer temperatures, changing pattern of rainfall throughout the year, short and early winter, and prolonged summer and longer droughts (Table 5).

Users reported that coppices of *S. wallichii* and *C. indica* trees in Thotne Khola Community Forest are dying due to higher summer temperatures, although *S. wallichii* is relatively drought resistant. Coppices of this species are also dying, due to more intense droughts. Fruits of *M. esculenta* have become less palatable and have accumulated more water due to more rainfall in early Chaitra season (mid-March to mid-April). This fruit is also ripening 10–15 days earlier than the usual time due to higher early winter temperatures. Users also observing that fruits of *M. esculenta* are becoming smaller whereas the seeds are increasing in size, i.e. the edible portion is declining over time. However, respondents were unable to explain the reason for changing fruit size. The flowering and fruiting pattern of *M. esculenta* is also changing due to climate change. One statement of a user about changing flowering and fruiting pattern of *M. esculenta* was "previously if one fruit of *M. esculenta* was harvested from one position of trees then another fruit was found in the same position in the same fruiting season but now after harvesting one fruit no other fruit in same position in the same season is found". CFUG have noticed that higher early winter temperatures are the main cause for changing flowering and fruiting patterns of *M. esculenta*.

Pest infestation, wilting of trees and invasive plants are major concerns in Thotne Khola Community Forest management because the abundance and frequency of

Table 5 Forest users identified effects of climate change on Thotne Khola Community Forest

Identified effect	Climatic reasons	Local knowledge of identifications
Coppice of *Schima wallichii* and *Castanopsis indica* are dying	Higher summer temperatures	If there is no rainfall in late Chaitra (March) coppice are affected. Now rainfall is delayed
Fuelwood collection is 1 month delayed	Delayed rainfall	Previously fuelwood was collected in Magshir (Nov–Dec) but now Poush–Magh (Jan–Feb)
Fruits of *Myrica esculenta* ripen 10–15 days earlier	Higher temperatures in early winter	Before it was ripen in Chaitra (March–April) but now earlier
Damura (local name, scientific name unknown) ripens 10–15 days earlier	Higher temperatures in early winter	Before it was ripen in Chaitra but now earlier
Less taste and more water content in fruits of *Myrica esculenta*	More rainfall in early Chaitra	If droughts in Chaitra then same taste
Previously ant infestation found in summer only but now whole year	Less rainfall across whole year	Usually found in dry (Magh) (Jan.–Feb) but now whole year
More infestation of larva in *Alnus nepalensis* tree	Higher summer temperatures and delayed rainfall	Rainfall washed away the larva, so delayed rainfall helps to spread over whole area
Larva infestation in *Alnus nepalensis* for longer period	Higher average annual temperatures	Previously it was found in Poush and Magh (Jan.–Feb) but now up to Boishak (May) i.e. retain more 3 months
Larva infestation in other trees	Higher average annual temperatures	Previously found in *Alnus nepalensis* only, but now found in other trees also
More wilted trees	Higher summer temperatures, more droughts and prolong summer	Previously found in Magh–Fagun (Feb.–March) but now up to Boishak–Jashto (May–June)
More abundance of invasive plants *Eupatorium adenophorum*	Higher annual temperatures, early summer rainfall	Initially found only in river banks but now everywhere
More abundance of invasive plants *Mimosa rubicaulis*	Higher annual temperatures, early summer rainfall	Initially found in only river banks but now everywhere
More abundance of invasive plants Moru (local name, scientific name unidentified)	More landslides	Usually found more in the landslides area
Greater mortality of seedlings and saplings	More droughts	Users were unable to provide more information
Dying of Tejpata (C*innamomum tejpata*) and Sarpaganda (*Rauvolfia serpentine*)	Higher temperature in early winter	Died due to Unusual higher temperature in Chaitra 2011 (March–April)

pest infestation, wilting of trees and invasive plants are increasing over time. Users recognized and explained that climate change is responsible for the increased intensity of pest infestation, wilting of trees, and increase in invasive plants. Users described that previously ant infestation was found in the dry season only but now it is found throughout the year due to less annual rainfall. One type of larva infestation which is locally known as Utish larva, because it is found in Utish trees (*A. nepalensis)*, has been more frequent in recent years. The reasons are higher summer temperatures and delayed rainfall. The larva first attack either in the treetop or in the main stem then make a large channel into the main stem (Fig. 2), subsequently leading eventually to the dying of tree in part or whole. Previously larval infestation was found in *A. nepalensis* only but now it is also found in other tree species. Previously wilted trees were rarely found but now tree wilting is common in Thotne Khola Community Forest. Users reported that less rainfall and higher temperatures are the cause of tree wilting. A high number of ant-infected, larva-infected and wilted trees was also found during the field visit in Thotne Khola Community Forest.

Apart from diseases and pest infestation, users reported that abundance of previously observed invasive plants is increasing as well as new invasive plants being found. During the field visit, it was found that invasive plants Bonmara (*Eupatorium adenophorum*) and Bokshiful (*Mimosa rubicaulis*) are pervasive across a large area of the Thotne Khola Community Forest (Fig. 2). In addition, landslides due to concentrated high rainfall events are increasing both in frequency and magnitude. The community forest user group harvests fruit of *M. esculenta* 10–15 days earlier than the typical harvest time in the past. Previously, fuelwood was collected in November–December but now due to late rainfall, they collect fuelwood in January–February. Thotne Khola Community Forest User Group has planned to cultivate medicinal plants in Thotne Khola Community Forest on a commercial basis. Accordingly, they established trial plots of Kurilo (*Asparagus officinalis*), Tejpata (*Cinnamomum tejpata*) and Sarpaganda (*Rauvolfia serpentine*) in Thotne Khola Community Forest in 2011 (Fig. 2). Unfortunately, the seedlings of Tejpata and Sarpaganda have now died due to unusually high temperatures in Chaitra season 2011 (March–April).

Discussion

Schima wallichii and *C. indica* are dominant trees in Thotne Khola Community Forest. The main objective of handing over Thotne Khola Community Forest to the community management was to re-establish the forest through coppice regeneration of *S. wallichii* and *C. indica,* thereby ensuring community benefits (Baral 2011). *S. wallichii* and *C. indica* mixed forests in the middle hill zone in Nepal are considered as the most useful forest types because local people collect fuelwood, leaf fodder and timber from these species to meet their needs (Springate-Baginski et al. 2003). As coppices of *S. wallichii* and *C. indica* are dying due to warming climate and changes in precipitation (Table 5), forest recovery is being disturbed and the proportion of *S. wallichii* and *C. indica* trees is declining. Hence, it is apparent that

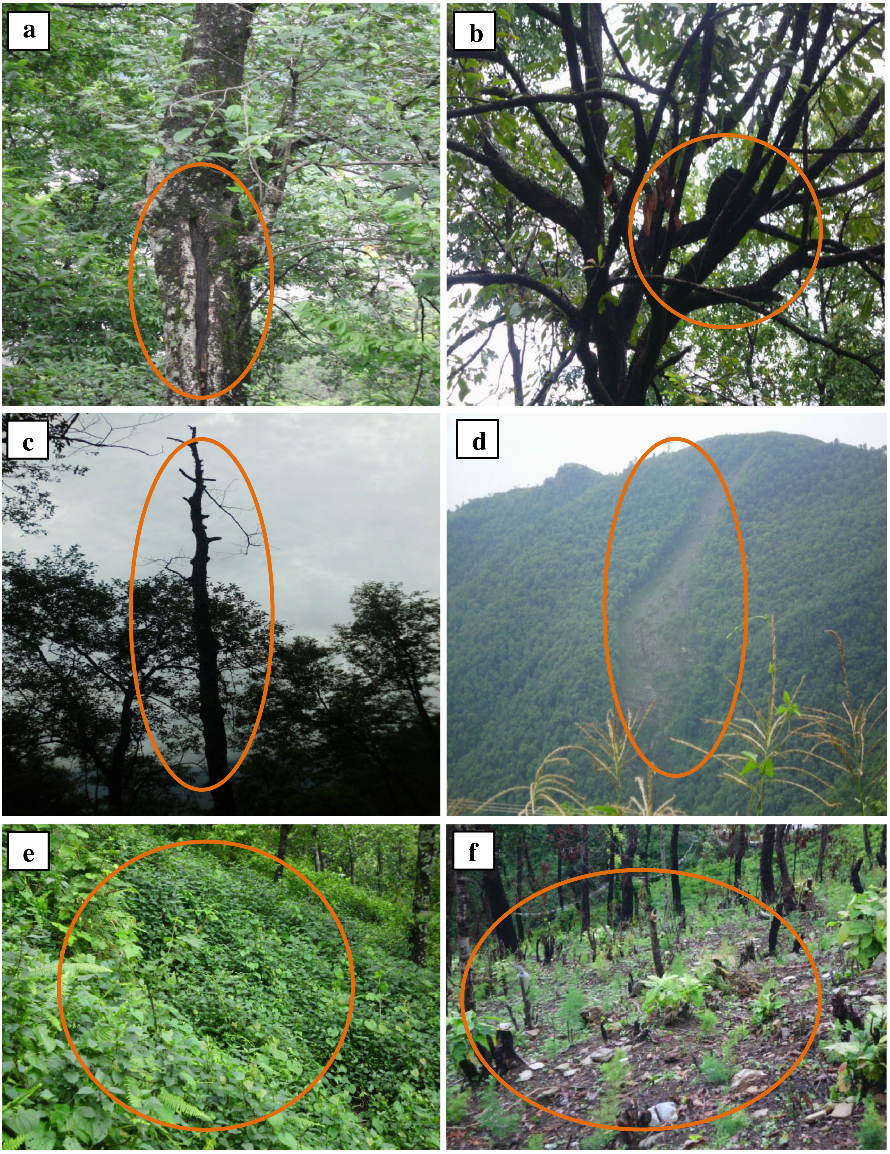

Fig. 2 Photos of users identified climate change effects on community forests: **a** pest infestation in *A. nepalensis* tree; **b** ant infestation in trees; **c** wilted trees; **d** landslide; **e** invasion of *E. adenophorum*; *and* **f** dying of medicinal plants in a trial plot

under the current situation and management plan the main objective of community forest management would not be achieved for *S. wallichii* and *C. indica* mixed forests. Furthermore, in the long term this structural changes of *S. wallichii* and *C. indica* mixed forests will ultimately affect the ecosystem functioning of *S. wallichii* and *C. indica* mixed forests in the study area. It will also make *S. wallichii* and *C.*

indica dominated forests less important for the community and less financially viable.

Fitter and Fitter (2002) observed early flowering of 385 British plants due to climate warming. They argued that temperature is a key determinant of plant flowering time and plants phenology is changing progressively due to climate warming. Miller-Rushing and Primack (2008) observed early flowering of 43 North American plant species due to rising temperature. Amano et al. (2010) developed a 250 year index of first flowering date of 405 plant species in the UK to assess climate change impacts on plant communities. They also observed early flowering of plants due to climate change. Guo et al. (2013) observed early flowering of *Castanea mollissima* in China due to rising temperature. Vrsic et al. (2014) found the changes of ripening time of grapes in Slovenia due to warming climate. Garcia-Mozo et al. (2010) also observed changes in fruit ripening time due to warming climate in Spain. Vedwan and Rhoades (2001) reported changing pattern of apple flowering and degradation of quality of apple in the Western Himalayan region due to changing pattern of temperature and precipitation. The IPCC (2007) has also projected phenology will be affected in the Himalayas due to a warmer climate. In this study, users reported changing of fruit size, particularly reductions in the edible portion, changes in fruit ripening time, loss of taste and changes in flowering and fruiting time patterns of trees in Thotne Khola Community Forest. Therefore, it is evident that user-identified climate change effects are aligned closely with scientific evidence. *M. esculenta* produces edible fruit, which are popular among community people and an important dietary protein source. Consequently, in the broader scale this effect is a threat for community wellbeing and natural structure and composition of community forest of Nepal. The similar effects may also be expected in other tropical countries where *M. esculenta* exists in forest ecosystems.

Moore and Allard (2008) stated that the pattern of forests pest infestation may change due to warming temperatures and changes in precipitation, because higher temperatures accelerate the development of insects and their reproductive capacity, and facilitate range expansion (Ayres and Lombardero 2000; Logan et al. 2003), ultimately leading to more insect infestations. Vedwan and Rhoades (2001) reported increased intensity of pest and disease in apples in the Western Himalayan region due to climate change. Simberloff (2000) stated that climate change helps invasive plants to out-compete non-invaders. Kleinbauer et al. (2010) observed that warming climate increases invasion of alien species potentially threatening endangered species out of their habitat. Climate change related disturbances, including landslides, facilitate entry of invasive species into the affected areas (Dukes and Mooney 1999). Subsequently large-scale invasion can alter ecosystem service provision (Le Maitre et al. 2011). Vicente et al. (2013) reported that the distribution of many invasive species will increase under climate change if there is no control action. In the present study, users identified changing patterns of pest infestation (more pest infestation in *A. nepalensis*, ant infestation), insect infestation in new species, increased abundance of invasive plants in forests and new invasive plants in landslides area (Fig. 2). Therefore, it is evident that local knowledge is useful for identifying climate change effects on forests and patterns of pest infestation and invasive plants are consistent with scientific observations.

Surprisingly, neither the CFUG nor the Forest Department are taking any counter measures against pest infestation, wilting of trees and invasive plants in the Thotne Khola Community Forest. CFUG considered these infected trees as the source of their income as users are allowed to cut these diseased and dried trees. The forest officials' think that, as people are living in and around the forest area, chemical control of these diseases and pests will affect the community and it is also a matter of income generation for CFUG (Baral 2011). CFUG are greatly concerned about invasive plants management. During other forestry operations CFUG remove these invasive plants but now these are out of control.

Policy Implications

In Nepal, Community forests are managed under a 5-year operational plan, which is prepared by the respective CFUG with technical support from the Forest Department. Any adaptation measure is not possible without inclusion into the operational plan. The operational plan for the studied community forest was prepared in 1998 and was revised in 2004. However, in the revision nothing was included in regard to climate change adaptation or biodiversity conservation. The study revealed that due to climate change species composition of *S. wallichii* and *C. indica* dominant mixed forests may change, quantity and quality of forests stocks may be reduced, useful plant species will face greater competition from invasive plants and biodiversity will be reduced. Hence, the whole forest ecosystem may be compromised with substantial effects on the livelihoods of the community forest user group and the condition of the natural forest ecosystems. Therefore, for the continuity of sustainable community forest management and biodiversity conservation under anticipated climate change it is necessary to develop an adaptation plan for climate change accommodating the knowledge of the community forest user group and their aspirations. The adaptation plan must be included into the operational plan and implementation under the control of the CFUG should be ensured.

The disease and pest outbreaks in community forests should not be considered as a source of fuelwood and income for the user group rather they are a threat for the long-term sustainability of forest management, biodiversity conservation, sustainable forest dependent livelihood management and community development. Various silvicultural adaptation options including planting of mixed species, and disease resistant species, and pruning would be important options. In addition, a plan for weed removal, including killing of invasive plants just after the first summer rainfall will reduce the abundance of invasive plants, ant and pest infestation (a recommendation from users). Further research on the fruits of *M. esculenta* to ascertain the exact reasons for loss of taste, reduction of edible parts and accumulation of more water is needed. Research to examine the adaptation strategies of *S. wallichi* and *C. indica* coppice with increasing summer temperatures is also needed.

Concluding Remarks

The Thotne Khola Community Forest User Group was able to identify the changes in forest structure and composition. They were also able to describe the cause of each change using their local knowledge, and most of the causes appear to be related to climate change. It is also found that climate change effects on the Thotne Khola Community Forest identified by the Thotne Khola Community Forest User Group are highly aligned with the mainstream scientific observations available in the published literature. So CFUGs' knowledge is useful to identify climate change effects on community forests in Nepal. Therefore it can be concluded that collection of local knowledge should be used as a legitimate approach on which to base climate change adaptation strategies, conservation planning and forestry-related policy in the developing world, where science-based information availability is often lacking.

Acknowledgments We acknowledge the contribution of Komal Kafle during research design and data collection phase. We thank Jhapendra Raj Subedi, Chairman, Thotne Khola Community Forest User Group for his amazing support during fieldwork. We thank Khagandra Raj Baral, Assistant Forest Officer, District Forest Office, Kaski, Nepal who helped collecting secondary information. We also thank Amrit Sarma who worked as an interpreter during fieldwork. We are grateful to Steve Harrison for his support for profound improvement of this manuscript.

References

Akhter S, Raihan F, Sohel MSI, Syed MA, Das SK, Alamgir M (2013) Coping with climate change by using indigenous knowledge of ethnic communities from in and around Lawachara National Park of Bangladesh. J For Sci 29(3):181–193

Amano T, Smithers RJ, Sparks TH, Sutherland WJA (2010) 250-year index of first flowering dates and its response to temperature changes. Proc R Soc B 277(1693):2451–2457

Anonymous (2009) Climate change impacts on livelihoods of poor and vulnerable communities and biodiversity conservation: a case study in Banke, Bardia, Dhading and Rasuwa Districts of Nepal. Strengthened Actions for Governance in Utilization of Natural Resources (SAGUN) Program, CARE Nepal, Kathmandu, Nepal

Ayres MP, Lombardero MJ (2000) Assessing the consequences of climate change for forest herbivores and pathogens. Sci Total Environ 262(3):263–286

Baidya SK, Shrestha ML, Sheikh MM (2008) Trends in daily climatic extremes of temperature and precipitation in Nepal. J Hydrol Meteorol 5(1):38–51

Baral KR (2011) Assistant forest officer. District Forest Office, Kaski

Bhattacharya AK, Basnyat B (2003) An analytical study of operational plans and constitution of Community Forests User Groups at Nepal's Western Terai. Banko Jankari 13(1):3–14

Byg A, Salick J (2009) Local perspectives on a global phenomenon-climate change in eastern Tibetan villages. Glob Environ Change 19(2):156–166

Chaudhary P, Bawa KS (2011) Local perceptions of climate change validated by scientific evidence in the Himalayas. Biol Lett 7(5):767–770

Cruikshank J (1981) Legend and landscape: convergence of oral and scientific traditions in the Yukon Territory. Arctic Anthropol 18(1):67–93

Dahal N (2005) Perceptions of climate change in the Himalayas. Teimpo Bull. http://www.cru.uea.ac.uk/tiempo/newswatch/feature050910.htm. Accessed 24 Oct 2010

Department of Forests, Nepal (2012) CF database. DOF, Community Forestry Division, Nepal. www.dof.gov.np/index.php?option=com_content&view=article&id=95&Itemid=121 Accessed 15 Jan 2013

Du MY, Kawashima S, Yonemura S, Zhang XZ, Chen SB (2004) Mutual influence between human activities and climate change in the Tibetan Plateau during recent years. Global Planet Change 41(3–4):241–249

Duerden F (2004) Translating climate change impacts at the community level. Arctic 57(2):204–212

Dukes JS, Mooney HA (1999) Does global change increase the success of biological invaders? Trends Ecol Evol 14(4):135–139

Ebi KL, Woodruff R, Von Hildebrand A, Corvalan C (2007) Climate change related health impacts in the Hindu Kush–Himalayas. EcoHealth 4(3):264–270

Fitter AH, Fitter RSR (2002) Rapid changes in flowering time in British plants. Science 296(5573):1689–1691

Garcia-Mozo H, Mestre A, Galan C (2010) Phenological trends in southern Spain: a response to climate change. Agric For Meteorol 150(4):575–580

Gautam AP, Shivakoti GP, Webb EL (2004) A review of forest policies, institutions, and changes in the resource condition in Nepal. Int For Rev 6(2):136–148

Gautam MR, Acharya K, Tuladhar MK (2010) Upward trend of streamflow and precipitation in a small, non-snow-fed, mountainous watershed in Nepal. J Hydrol 387(3–4):304–311

Gentle P, Maraseni TN (2012) Climate change, poverty and livelihoods: adaptation practices by rural mountain communities in Nepal. Environ Sci Policy 21:24–34

Government of Nepal (2013) District maps, Local Governance and Community Development Programme, Ministry of Federal Affairs and Local Development, Government of Nepal. http://lgcdp.gov.np/home/map-district.php, Accessed 4 Feb 2013

Guo L, Dai J, Ranjitkar S, Xu J, Luedeling E (2013) Response of chestnut phenology in China to climate variation and change. Agric For Meteorol 180:164–172

Gurung A, Bista R, Karki R, Shrestha S, Uprety D, Oh S (2013) Community-based forest management and its role in improving forest conditions in Nepal. Small-scale For 12(3):377–388

IPCC (2007) Climate change 2007: synthesis report. In: Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core Writing Team, Pachauri RK, Reisinger A (eds). IPCC, Geneva

Jianchu X, Shrestha A, Vaidya R, Eriksson M, Hewitt K (2007) The melting Himalayas: regional challenges and local impacts of climate change on mountain ecosystems and livelihoods. ICIMOD Technical Paper, ICIMOD, Nepal

Kansakar SR, Hannah DM, Gerrard J, Rees G (2004) Spatial patterns in the precipitation regime of Nepal. Int J Climatol 24(13):1645–1659

King DNT, Skipper A, Tawhai WB (2008) Mauori environmental knowledge of local weather and climate change in Aotearoa—New Zealand. Clim Change 90(4):385–409

Kleinbauer I, Dullinger S, Peterseil J, Essl F (2010) Climate change might drive the invasive tree *Robinia pseudacacia* into nature reserves and endangered habitats. Biol Conserv 143(2):382–390

Le Maitre DC, Gaertner M, Marchante E, Ens EJ, Holmes PM, Pauchard AO, Farrell PJ, Rogers AM, Blanchard R, Blignaut J, Richardson DM (2011) Impacts of invasive Australian acacias: implications for management and restoration. Divers Distrib 17(5):1015–1029

Logan JA, Régnière J, Powell JA (2003) Assessing the impact of global warming on forest pest dynamics. Front Ecol Environ 1(3):130–137

Malla G (2008) Climate change and its impact on Nepalese agriculture. J Agric Environ 9:62–71

Manandhar S, Vogt DS, Perret SR, Kazama F (2011) Adapting cropping systems to climate change in Nepal: a cross-regional study of farmers' perception and practices. Reg Environ Change 11(2):335–348

Martello ML (2008) Arctic indigenous peoples as representations and representatives of climate change. Soc Stud Sci 38(3):351–376

Miller-Rushing AJ, Primack R (2008) Global warming and flowering times in Thoreau's concord: a community perspective. Ecology 89(2):332–341

Moller H, Berkes F, O'Brian LP, Kislalioglu K (2004) Combining science and traditional ecological knowledge: monitoring populations for co-management. Ecol Soc 9(3):2

Moore B, Allard G (2008) Climate change impacts on forest health. Forest health and bio security working papers. Working Paper FBS/34E. Room, Italy

Munang R, Thiaw I, Alverson K, Mumba M, Liu J, Rivington M (2013) Climate change and ecosystem-based adaptation: a new pragmatic approach to buffering climate change impacts. Curr Opin Environ Sustain. doi:10.1016/j.cosust.2012.12.001

Myers N, Mittermeier RA, Mittermeier CG, da-Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. Nature 403(6772):853–858

Regmi BR, Thapa L, Sharma GB, Khadka S (2008) Climate change risk, vulnerability and adaptation strategies at community level, local initiatives for biodiversity research and development (LI-BIRD)

Reidlinger D, Berkes F (2001) Contributions of traditional knowledge to understanding climate change in the Canadian Arctic. Polar Rec 37(203):315–328

Salick J, Ross N (2009) Traditional peoples and climate change. Glob Environ Change 19(2):137–139

Sharma SK (2011) The political economy of climate change governance in the Himalayan region of Asia: a case study of Nepal. Procedia Soc Behav Sci 14:129–140

Sharma E, Chettri N, Tse-ring K, Shrestha AB, Jing F, Mool P, Eriksson M (2009) Climate change impacts and vulnerability in the Eastern Himalayas. ICIMOD, Kathmandu

Shrestha AB, Wake CP, Mayewski PA, Dibb JE (1999) Maximum temperature trends in the Himalaya and its vicinity: an analysis based on temperature records from Nepal for the period 1971–94. J Clim 12(9):2775–2786

Shrestha AB, Wake CP, Dibb JE, Mayewski PA (2000) Precipitation fluctuation in the Nepal Himalaya and its vicinity and relationship with some large scale climatological parameters. Int J Climatol 20(3):317–327

Shrestha S, Karky BS, Gurung A, Bista R, Vetaas OR (2013) Assessment of carbon balance in Community Forests in Dolakha, Nepal. Small-scale For 12(4):507–517

Simberloff D (2000) Global climate change and introduced species in United States forests. Sci Total Environ 262(3):253–261

Springate-Baginski O, Dev OP, Yadav NP, Soussan J (2003) Community forest management in the middle hills of Nepal: the changing context. J For Livelihood 3(1):5–20

Vedwan N, Rhoades RE (2001) Climate change in the Western Himalayas of India: a study of local perception and response. Clim Res 19(2):109–117

Vicente JR, Fernandes RF, Randin CF, Broennimann O, Gonçalves J, Marcos B, Pôças I, Alves P, Guisan A, Honrado JP (2013) Will climate change drive alien invasive plants into areas of high protection value? An improved model-based regional assessment to prioritise the management of invasions. J Environ Manage 131:185–195

Vrsic S, Sustar V, Pulko B, Sumenjak TK (2014) Trends in climate parameters affecting winegrape ripening in northeastern Slovenia. Clim Res 58(3):257–266